

Figure 18. Expected radio noise power, F_a , and its standard deviation, σ_{F_a} , from 115 kV, H-frame power transmission line. Receiving antenna under and 0.01 mi. (16.09 meters) from power line.

4.2 The Average and Logarithmic Moments, V_d and L_d

As previously mentioned, the ratio of the rms to the average envelope voltage, V_d , in decibels, and the ratio of the rms to the antilog of the average logarithm of the envelope voltage, L_d , in decibels, are indicative of the impulsive nature of the noise (Crichlow et al., 1960).

Values of V_d and L_d are available from the same sets of measurements used to obtain the estimates of F_a . These data were separated into the same groupings as the values of F_a . Two bandwidths were used in taking the measurements, 4 kHz and 10 kHz. The earlier measurements were all made using the 10 kHz bandwidth. An analog tape recorder (Appendix A) was added to the measurement capability which limited the bandwidth that could be used to 4 kHz. Therefore, all of the latter measurements were made using the 4 kHz bandwidth. Since the values of V_d and L_d for radio noise are dependent on bandwidth, the data were further separated into subgroups of 4 kHz and 10 kHz data. The means of the individual location median values for each subgroup are shown plotted on figures 19 through 22. Figures 19 and 20 show values of V_d and L_d , respectively, for measurements made in a 4 kHz bandwidth for the three types of areas. Figures 21 and 22 are the corresponding measurements made using a 10 kHz bandwidth. The values of V_d and L_d for white Gaussian noise, which are independent of bandwidth and frequency, are also shown on figures 19 through 22. As with the values of F_a , there is a fairly large variation of the median values from location to location in a particular type of area. This variation is indicated in table 3 where the standard deviations of $V_d(\sigma_{V_d})$ and $L_d(\sigma_{L_d})$ are shown for the various types of areas, bandwidths, and frequencies.

As can be seen from figures 19 through 22, there is a definite difference in the character of the noise in the three types of areas. While

Table 3. Variation of the Median Value of V_d and L_d with Location
for a Given Frequency and Bandwidth

Frequency (MHz)	Standard Deviation of V_d , σ_{V_d} (dB)					
	Business Areas		Residential Areas		Rural Areas	
	BW 4 kHz	BW 10 kHz	BW 4 kHz	BW 10 kHz	BW 4 kHz	BW 10 kHz
0.25	1.6	2.2	1.1	1.8	0.6	1.0
0.5	1.2	2.6	0.2	1.2	0.6	0.6
1.0		1.0		0.9		2.3
2.5	2.5	2.6	1.6	2.6	2.0	1.7
5	1.3	1.1	1.4	1.3	0.5	1.0
10		1.5		1.9		0.9
20	2.2	1.8	1.4	1.4	1.4	0.9
48	1.6	1.4	1.8	1.8	1.4	0.4
102	1.4		1.8		1.3	
250	0.7		0.5		0.5	
Average	1.6	1.8	1.2	1.5	1.0	1.1

Frequency (MHz)	Standard Deviation of L_d , σ_{L_d} (dB)					
	Business Areas		Residential Areas		Rural Areas	
	BW 4 kHz	BW 10 kHz	BW 4 kHz	BW 10 kHz	BW 4 kHz	BW 10 kHz
0.25	3.1	3.7	1.2	2.7	1.3	1.1
0.5	2.7	4.3	0.6	2.1	1.2	1.1
1.0		1.3		1.2		3.2
2.5	4.2	4.2	1.8	3.5	2.3	2.9
5	1.8	2.0	2.0	1.8	0.9	1.4
10		2.1		2.5		1.3
20	3.3	3.2	2.3	2.4	1.9	1.0
48	2.5	2.7	2.2	2.7	1.4	0.5
102	2.2		2.6		2.8	
250	1.1		1.0		0.6	
Average	2.6	2.9	1.6	2.0	1.6	1.6

there is considerable overlap, considering the values in table 3, the general trends are fairly well defined. Figures 23, for business areas, 24, for residential areas, and 25, for rural areas, give the expected median values of V_d and L_d . The solid line is the estimate for a 4 kHz bandwidth and the dashed for 10 kHz. These are estimates for the mean of the individual location median values. The estimates are based on least squares polynomial fits to the measurement data. As with F_a , the distribution of the location medians, in decibels, can be represented quite well by a normal distribution. The values of σ_{V_d} and σ_{L_d} shown in table 3 can be used in the same manner as σ_{F_a} in table 1 to determine the probability of a median value occurring at any location within a particular type of area.

There will be a variation about the location median with time at any given location, which will generally be larger than the variation from location to location. Again, as with F_a , this variation within an hour can be represented quite closely by a skewed normal distribution, defined by the median and upper and lower decile values. Using the same 20 MHz residential area recordings used to obtain within the hour variation of F_a (fig. 3), a distribution of the 10-sec readings of V_d is shown on figure 26 and of L_d on figure 27. These distributions are typical of those generally found in business and residential areas. The distributions found in rural areas will have the same form but will usually be much flatter. The ratio, in decibels, of the upper decile to the median value of the distribution shown on figure 26 is 4.8 dB. The average value of this ratio for 20 MHz rural area data is 0.8 dB. Similarly, the ratio of the upper decile to the median for the distribution of the L_d values in figure 27 is 7.0 dB, while the corresponding rural average value is 1.0 dB.

Interstate highways and parks and university campuses were analyzed separately for values of V_d and L_d . The results are shown on figures 28 for V_d and 29 for L_d , with the measurement bandwidth indicated. The results for both V_d and L_d from the interstate highway measurements are similar to the business area estimate above 10 MHz and similar to the rural area estimate at lower frequencies. This is to be expected, since the man-made noise is caused predominately by ignition systems at the higher frequencies and power lines at the lower frequencies.

The park and university campus curves appear to fall somewhere between the residential and rural curves. Most parks and campuses have somewhat restricted traffic patterns and few overhead power lines and would be expected, therefore, to approach the general rural conditions.

As with the values of F_a , the values of V_d and L_d were measured using a short vertical antenna. There is even less information on the effect of polarization on V_d and L_d than there is on F_a . At the time the 250 MHz data shown on figure 13 were recorded, the values of V_d for the two antennas were also recorded. These data are shown plotted on figure 30 along with the best fit regression line. As can be seen, the value of V_d for the vertical component is generally larger than the value for the horizontal component. The recorded man-made radio noise in this case was almost exclusively from automotive ignition systems. This relationship would indicate that the vertical component was more impulsive for ignition noise than the horizontal component. However, the sample size was extremely small (17 sets of 10 sec measurements).

Two computer plots of the relationships between the three moments, F_a , V_d , and L_d , are interesting. The high degree of correlation between V_d and L_d is shown on figure 31. The values of 673 V_d and the corresponding L_d location medians obtained by combining the data for

all frequencies and locations are plotted. Since the values of both V_d and L_d are dependent upon the instantaneous variations of the noise envelope, a fairly high correlation between the two values would be expected. With as high a correlation coefficient ($r = 0.94$) as was obtained, the value of V_d may give an adequate definition for the most likely APD as was found to be the case with atmospheric radio noise (Crichlow et al., 1960; CCIR, 1964). Figure 32 shows the lack of correlation between V_d and F_a . The very low correlation coefficient ($r = -0.07$) shown by the 673 pairs of V_d and F_a indicates that the character of the noise, that is the impulsive nature or instantaneous envelope variations, is not dependent upon the power level. It is a function of the types and number of sources of the composite man-made radio noise and their distribution about the receiving antenna and not of the actual received power level.

Since man-made noise is white (flat spectrum over normal communications bandwidth), the values estimated for F_a are independent of bandwidth as long as bandwidths limited to a few percent of the center frequency are considered. Since the values of V_d and L_d are dependent on bandwidth, the estimates given here are only applicable to these measurement bandwidths.

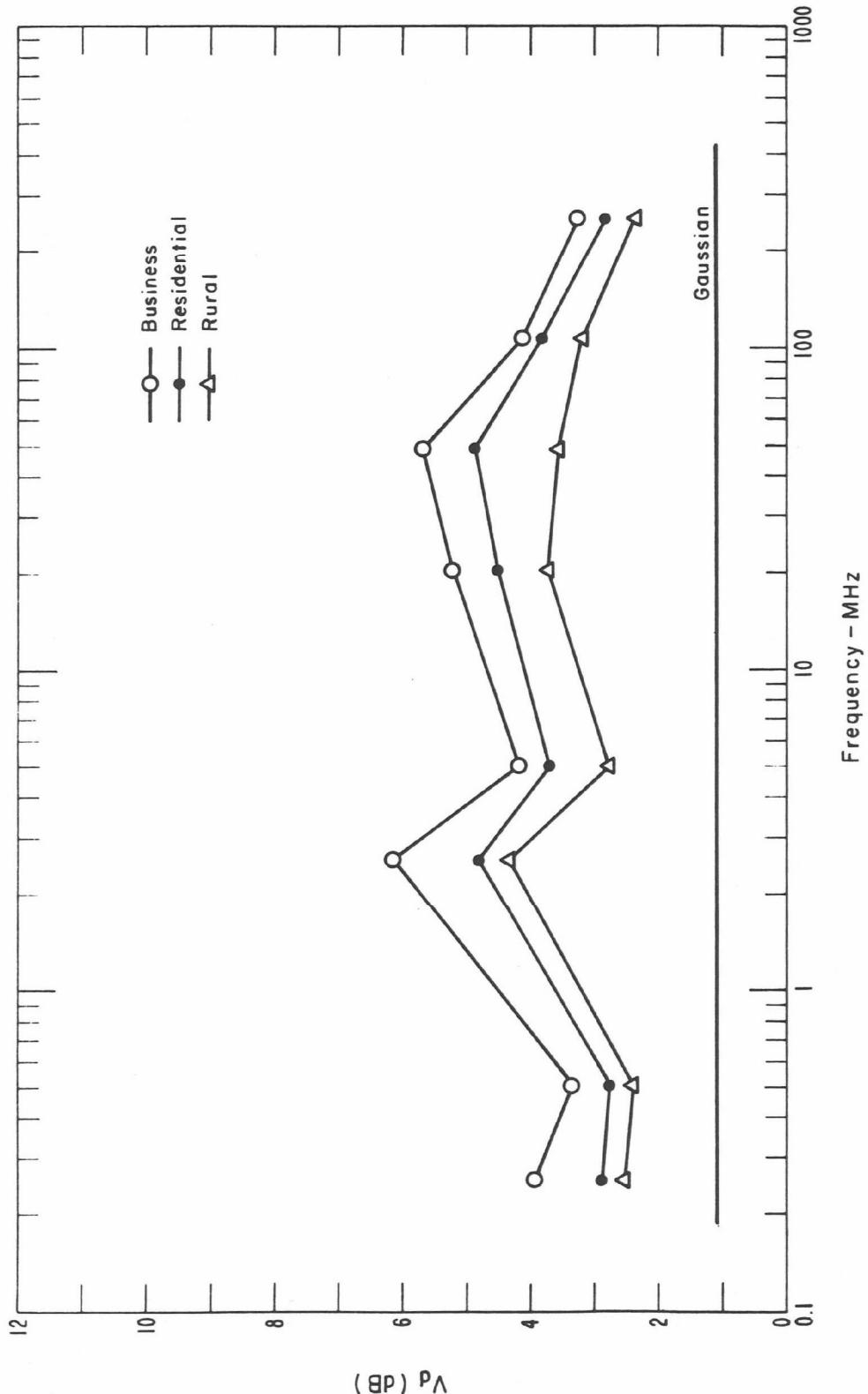


Figure 19. Mean of location median values of V_d , values measured in a 4-kHz bandwidth.

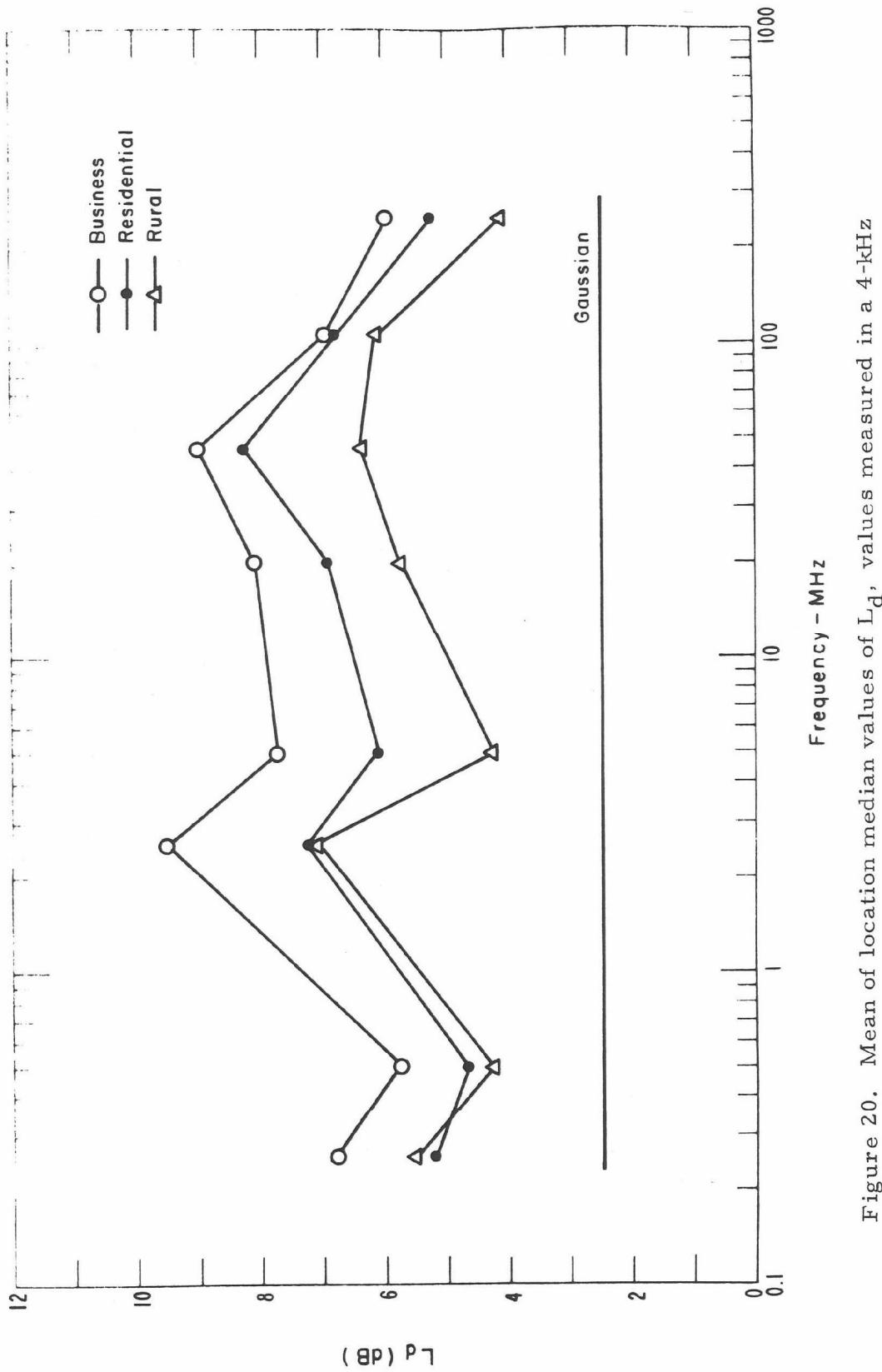


Figure 20. Mean of location median values of L_d , values measured in a 4-kHz bandwidth.

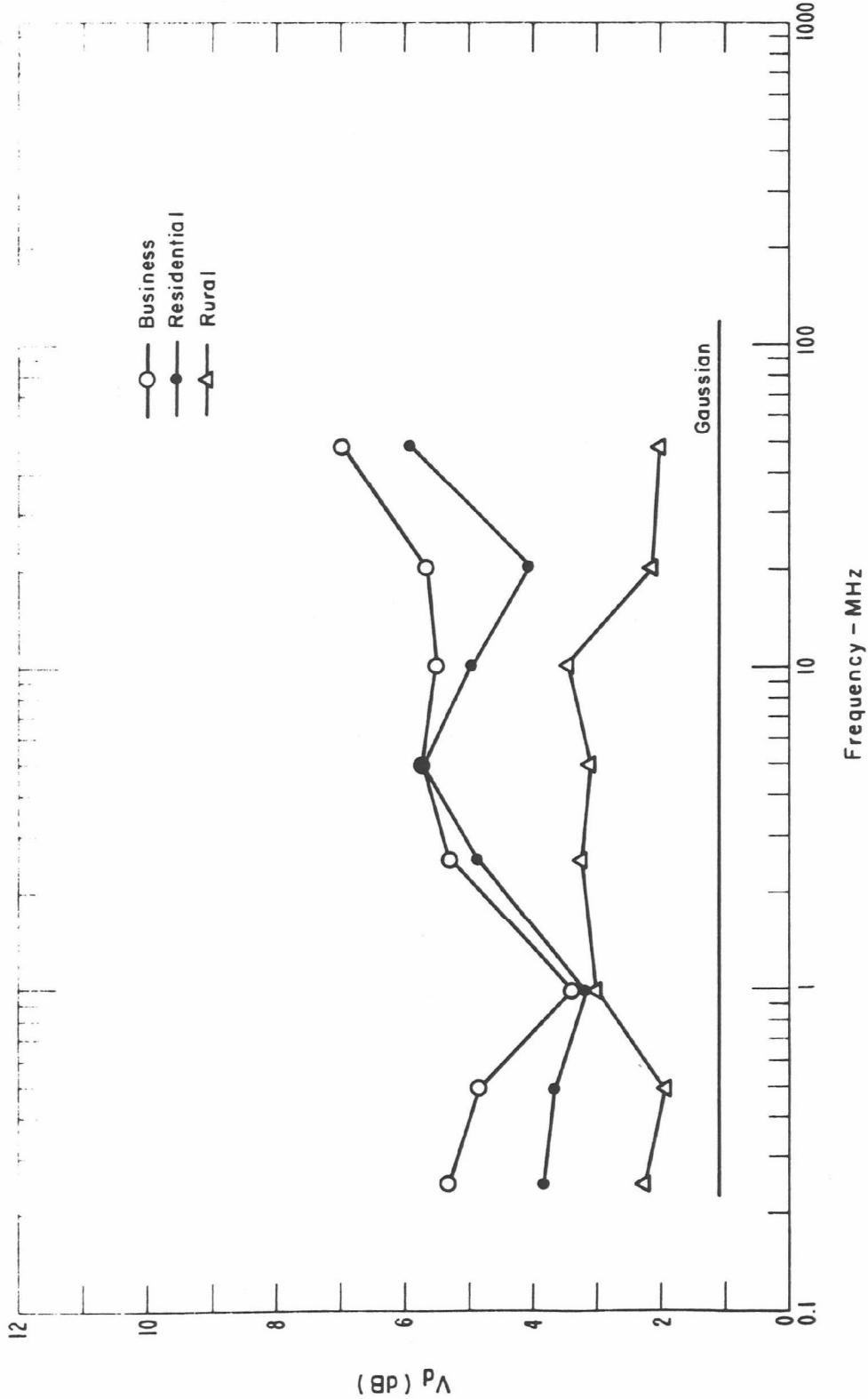


Figure 21. Mean of location median values of V_d , values measured in a 10-kHz bandwidth.

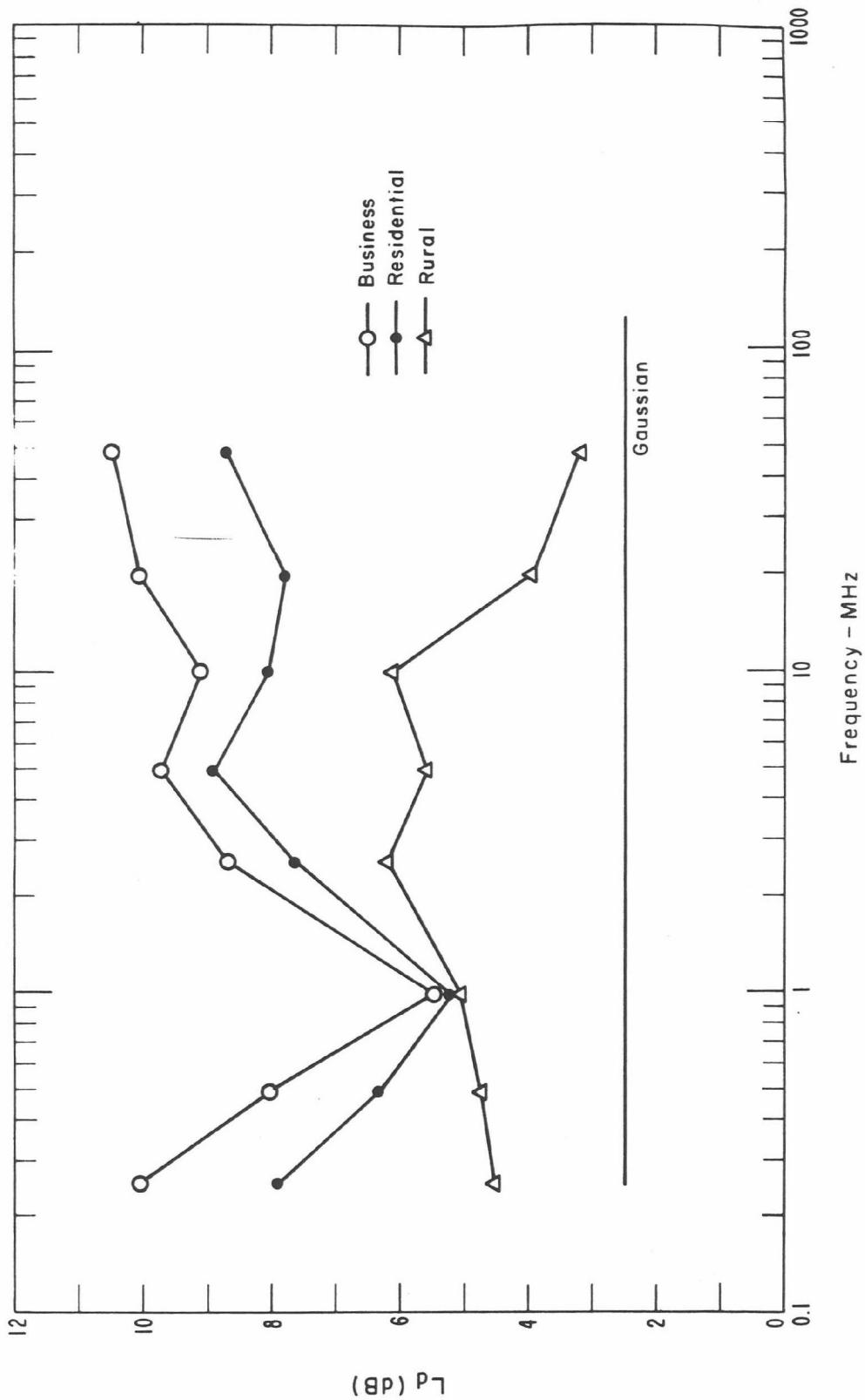


Figure 22. Mean of location median values of L_d , values measured in a 10-kHz bandwidth.